

Appl. No. 10/024,838
Amdt. dated June 8, 2004
Reply to Office Action of March 8, 2004

Remarks/Arguments:

Applicants respectfully request reconsideration of this application in view of the foregoing amendments to the claims and the following comments.

In the Office Action mailed March 8, 2004, independent claims 1 and 19, and dependent claims 3, 5, 6, 9, 13, 15, 16, 20, 22, 24, 25, 28, 29, and 32, were rejected under 35 U.S.C. 102(b), as allegedly anticipated by U.S. Patent No. 5,888,592 to Biallas et al. (the "Biallas patent"). Further, dependent claims 2, 4, 7, 8, 10-12, 14, 17, 18, 21, 23, 26, 27, 30, 31, and 33-38 were rejected under U.S.C. 103(a), as allegedly obvious over the Biallas patent, taken either alone or in light of U.S. Patent No. 6,125,549 to Pikus (the "Pikus patent"), U.S. Patent No. 5,856,018 to Chen et al. (the "Chen patent"), or U.S. Patent No. 5,319,861 to Tate (the "Tate patent").

Applicants respectfully traverse the Examiner's rejections. In response to the rejections, Applicants have amended independent claims 1 and 19, to clarify the distinctions of the claimed invention over the cited patents. Amended independent claims 1 and 19, and their respective dependent claims 2-18 and 20-38, should now be allowed.

I. The Invention

The present invention resides in an improved apparatus, and related method for using it, to rapidly cure a sol-gel coating adhered to a substrate, without warping or otherwise damaging the substrate. The apparatus includes a heating source configured to generate a predetermined heating pattern and an assembly configured to sequentially expose discrete portions of the coated substrate to the heating pattern at a selected distance and for a selected duration, such that the heat energy sufficiently cures or densifies the sol gel coating, but does not unduly heat the substrate to cause deformation. At each moment during the cure, only a limited, discrete portion of the coated substrate is exposed to the heating source.

In a more detailed, optional feature of the invention, the heating source preferably includes two modes for heating the sol-gel coating for densification: IR radiation and hot gas.

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This transfers heat to the sol-gel layer from both its inside, i.e., the side contacting the plastic substrate, and its outside, i.e., the side exposed to the ambient. In another more detailed feature, optional of the invention, moisture can be introduced into the curing process by injecting steam, or other water forms, into the heated gas stream. In yet another more detailed, optional feature of the invention, the temperature of the heated gas stream is in the range of about 100 to about 500° C, and the flow rate of the heated gas stream is in the range of about 50 to about 10,000 cubic centimeters per second.

Preferably, the coated substrate is sequentially exposed to the heating source at a predetermined speed, e.g., about 0.5 to about 50 centimeters per second. This speed is selected to allow sufficient heat to flow into the sol-gel layer to densify the film and achieve the best optical and mechanical properties.

The invention is particularly beneficial for sol-gel oxide coatings, e.g., SiO₂ and TiO₂, used for optical coatings and for antireflection coatings. The sol-gel coatings themselves can withstand high temperatures, in excess of 500° C. At such high temperatures, a very rapid cure (densification) can be effected. However, for coatings adhered to substrates having a relatively low melting temperature, such high temperatures could damage the substrate. Preferably, the substrate and sol-gel coating are heated using a combination of heating modes to as high a temperature as possible for a short duration of time, providing the required densification of the sol-gel films, but without damaging the substrate. The process can be repeated to produce a product having multiple layers of sol-gel coatings.

II. The Anticipation Rejection

As mentioned above, claims 1, 3, 5, 6, 9, 13, 15, 16, 19, 20, 22, 24, 25, 28, 29, and 32 were rejected under 35 U.S.C. § 102(b), as allegedly anticipated by the Biallas patent. Applicants respectfully traverse this rejection: The Biallas patent fails to disclose an apparatus or method for rapidly curing a sol-gel coating as defined in these claims.

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More particularly, the Biallas patent discloses a laboratory drier for curing an industrial lacquer coated onto a substrate. The drier includes two adjacent chambers: a closed irradiation space 1 and a closed convection space 2. In use, the coated substrate initially is transported into the irradiation space, where the entire substrate is irradiated by a plurality of IR emitters, and it then is transported into the convection space, where again the entire substrate is exposed to drying gases supplied through a plurality of inlet slits 13. Thus, throughout the curing process, the entire coated substrate is exposed either to the IR emitters or to the drying gases.

This contrasts with the apparatus and method of Applicants' invention, in which a sol-gel coating on a substrate is cured by sequentially exposing only discrete segments of the coating to a heating source. The heat energy provided by the heating source is sufficient to deform the substrate if its exposure time is unlimited, but each discrete segment is exposed to the heating source for only a "selected" (i.e., limited) time duration. In this way, the coating is cured without unduly heating the underlying substrate. Applicants have amended independent claims 1 and 19 to clarify these distinctions over the disclosure of the Biallas patent.

More particularly, independent claim 1 defines a rapid-cure apparatus, including, (1) a supporting structure, (2) a heating source mounted on the supporting structure and configured to generate a predetermined heating pattern, and (3) a transfer assembly configured to sequentially expose portions of the coated substrate to the heating pattern at a selected distance and for a selected time duration, such that the heat energy sufficiently cures or densifies the sol-gel coating, but does not unduly heat the substrate to cause deformation. In addition, claim 1 has now been amended to clarify the meaning of the term "portions." Specifically, that term has been replaced by the term "discrete segments." Thus, at all times, only limited, "discrete segments" of the coated substrate are exposed to the heating pattern. This feature was inherent in the original claim language, because of its inclusion of the term "sequentially": the coated substrate could not be "*sequentially* expose[d]" if it were exposed non-discretely, i.e., in its entirety.

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Similarly, independent claim 19 defines a process for rapidly curing a sol-gel coating adhered to a substrate, including sequentially exposing portions the coated substrate to a heating source at a selected distance and at a selected rate, wherein the heat energy sufficiently cures or densifies the sol-gel coating to its optimum physical and optical properties, but does not unduly heat the substrate to cause deformation. In addition, claim 19 has now been amended to clarify that "sequentially exposing" applies to "discrete portions" of the coated substrate. This feature was inherent in the original claim language, because of its inclusion of the term "sequentially": the coated substrate could not be "*sequentially* expos[ed]" if it were exposed non-discretely, i.e., in its entirety.

For this reason, independent claims 1 and 19, as amended, should now clearly distinguish over the disclosure of the Biallas patent. Accordingly, the anticipation rejection of claims 1 and 19 should be withdrawn.

Claims 3, 5, 6, 9, 13, 15, and 16 all depend from amended independent claim 1, and claims 20, 22, 24, 25, 28, 29, and 32 all depend from amended independent claim 19. These dependent claims all define the invention with greater particularity and further distinguish over the Biallas patent. For this reason, and for the reasons set forth above with respect to independent claims 1 and 19, the anticipation rejection of these dependent claims should be withdrawn.

III. The Obviousness Rejection

As mentioned above, claims 2, 4, 7, 8, 10-12, 14, 17, 18, 21, 23, 26, 27, 30, 31, and 33-38 were rejected under 35 U.S.C. § 103(a), as allegedly obvious in view of the Biallas patent, taken either alone or in combination with the Pikus patent, the Chen patent, or the Tate patent. Applicants respectfully traverse this rejection.

The deficiencies of the Biallas patent are discussed above in connection with the anticipation rejection, and the Pikus, Chen and Tate patents all fail to make up for the deficiencies of the Biallas patent. The cited patents, taken either alone or in combination, all fail

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to show or suggest an apparatus or method for rapidly curing a sol-gel coating as defined in these claims. For this reason, and for the reasons set forth above with respect to independent claims 1 and 19, the obviousness rejection of these claims should be withdrawn.

IV. Other Matters

Applicants also have corrected an inadvertent misspelling of the term "densifies" in independent claims 1 and 19.

V. Conclusion

This application should now be in condition for a favorable action. Allowance of the claims is respectfully requested. If the Examiner believes that prosecution of the application might be expedited by a telephone conference with Applicants' undersigned representative, she is respectfully requested to call at the telephone number indicated below.

Date: June 8, 2004

Respectfully submitted,
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